WATER BALANCE DATA EVALUATION - WEYBURN AREA

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INTRODUCTION

Soil water content is one of the most important parameters determining plant growth and microbial activity in the prairie soils. The seasonal distribution of soil-moisture characterizes plant growth in relation to climate and variability of weather better than any single climatic parameter (Baier, 1979).

This study attempts to utilize a soil moisture model to predict moisture redistribution over the 1975 and 1976 growing seasons in selected fields in the Weyburn area.

MATERIALS AND METHODS

The selected site (Schnell) was described in a report by Anderson and Wilkinson (1976). A transect was established across a representative field and plots were selected along the transect. Plots were selected on the four most common subgroup profiles (Table 1) and each profile was

Table 1. The subgroup profiles or series in the selected site in this study (from Anderson and Wilkinson, 1977).

Symbol	Association	Subgroup
AMA	Amulet	Orthic Dark Brown
BKW	Brooking	Solonetzic Dark Brown
BKY	Brooking	Solodic Dark Brown
TCT	Trossachs	Dark Brown Solodized-Solonetz

replicated 4 to 6 times (except for the Solodized-Solonetzic profile, where one replicate only was taken). The approximate location of each profile in the landscape is shown in Fig. 1.

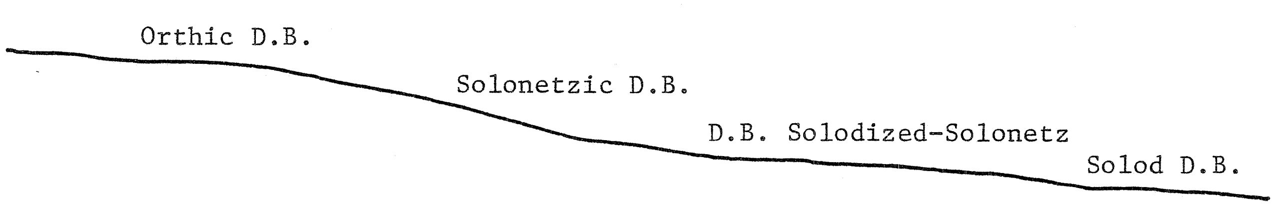

Fig. 1. Approximate location of the profiles included in this study.

Productivity related parameters and yield data for the area are presented by Anderson and Wilkinson (1977). Soil moisture levels were measured at seeding and during the growing season (Table 2) using the neutron moisture probe.

Table 2. Soil moisture sampling dates in 1975 and 1976.

1975	1976
May 29*	May 18*
June 24	June 15
July 9	July 6
July 30	July 22
August 14	August 10

*Seeding

The model used (Baier et al., 1979; de Jong, 1974) is driven by climatic, soil and plant parameters (Fig. 2). The water is withdrawn simultaneously from different depths in the soil depending on the potential evapotranspiration rate, rooting pattern of the crop and amount of available water present. The main theoretical deficiency of the model is the fact that water movement in the soil is presumed to occur only during infiltration. Hence, the soil is assumed to reach field capacity on the day the rain fell and after that no further movement occurs.

Total actual evapotranspiration is obtained by summation of the water withdrawal over all layers of the soil profile. Recharge of soil moisture occurs during rainfall or snowmelt. Air temperature determines whether the precipitation occurs as rain or as snow and when snowmelt occurs. In the present study the precipitation input was in the form of rain since the soil moisture was studied during the growing season.

Available water was calculated as the difference between the moisture (v/v) held at field capacity (highest % moisture reading per zone) and that held at permanent wilting point (½ of highest % moisture reading per zone). As the soil moisture data were measured by 15-cm intervals, seven standard zones were adopted accordingly (Table 3).

The root activity coefficients reflect the amount of water that is extracted by plant roots from the different zones during the growing season as a function of the potential evapotranspiration. These coefficients depend on the crop development stage (Baier et al., 1979). The crop coefficients used in the present study were obtained by interpolation of the crop coefficient values reported by Baier et al. (1979) for small grains (Fig. 3).

A detailed description of the model, computer program listings and user instructions can be found in the Matador Technical Report No. 61 (de Jong, 1974) or the updated version of the "Versatile Moisture Budget" by Baier et al. (1979).

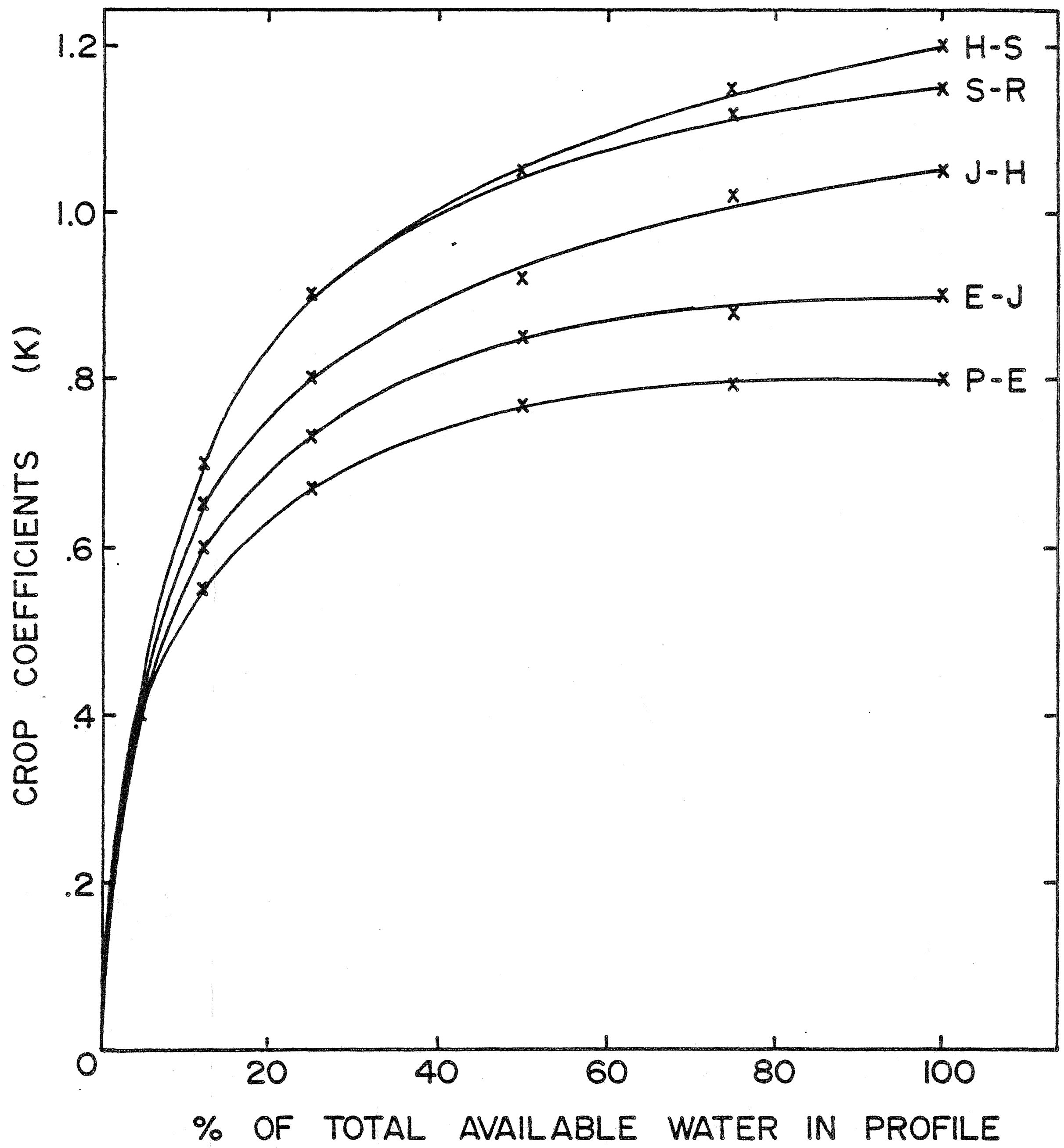

Fig. 3. Interpolated values of crop (K) coefficients reported by Baier et al. (1979) for small grains. Symbols used to define stages: P = planting, E = emergence, J = jointing, H = heading, S = soft dough, R = ripening.

Table 3. Standard soil zones and permanent wilting point and capacity of each zone.

Depth cm	Permanent wilting point %				Capacity cm			
	AMA	BKW	BKY	TCT	AMA	BKW	BKY	TCT
0-15	12.03	12.03	11.20	14.67	1.83	1.83	1.71	2.23
15-30	10.18	12.36	11.05	12.00	1.55	1.88	1.68	1.83
30-45	12.16	13.02	12.55	13.70	1.85	1.98	1.91	2.09
45-60	12.50	13.09	12.90	13.35	1.91	1.99	1.97	2.04
60-75	12.28	13.11	13.05	13.10	1.87	2.00	1.99	2.00
75-90	11.83	13.16	12.95	13.10	1.80	2.01	1.97	2.00
90-105	12.07	13.18	13.08	12.45	1.84	2.00	1.99	1.90

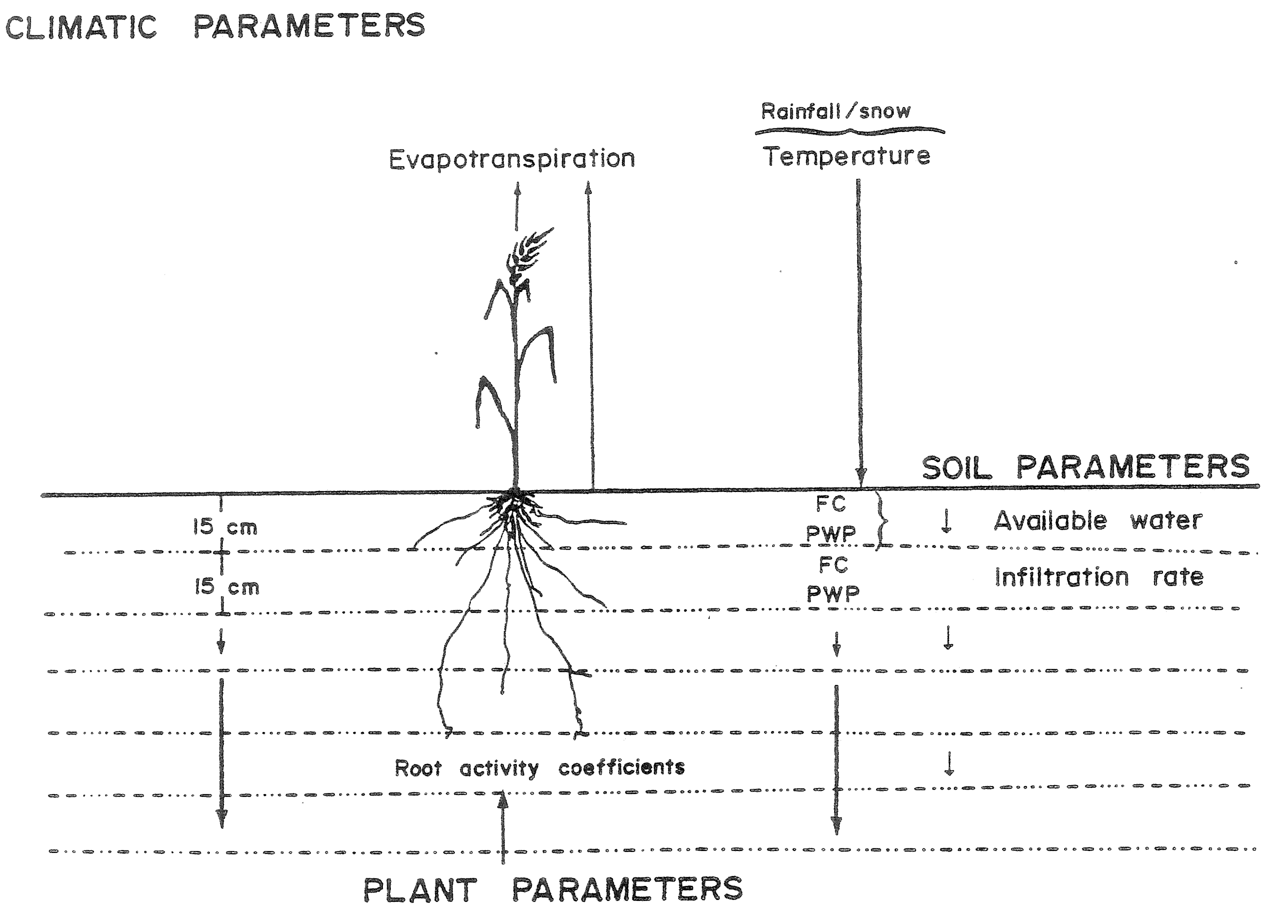

Fig. 2. Outline of the parameters used in the model.

RESULTS AND DISCUSSION

The output of the computer model for the four profiles studied for the 1975 and 1976 growing seasons is shown in Figs. 4 through 7. High variability in the soil moisture measurements is evident. However, three main trends can be recognized, namely, the predicted values for soil moisture in the Orthic Dark Brown profile were in close agreement with the actual ones; the predicted values for soil moisture in the rest of the profiles were lower than the actual values in 1975; and those predicted for 1976 for depths below 15 cm consistently higher than the actual ones. In contrast, the predicted values for the top 15 cm in 1976 were lower than the actual ones in most cases.

The main reasons for discrepancies between predicted and observed moisture levels in any run are:

1) Time of the day that soil moisture measurements were taken; e.g., if soil moisture was measured in the morning and it rained in the afternoon, the predicted moisture content would be higher than the observed rate.

2) Differences in the rainfall between plots and the meteorological site.

The above reasons could only partially explain the discrepancies between predicted and observed soil water contents. However, it would appear that the major reason for the discrepancies between the predicted and the actual values of soil water content are related to the presence of the Solonetzic soils in the area under consideration. The hard impermeable Bnt horizons of these soils impede water infiltration, hence, infiltration rates under field conditions are much slower than the ones assumed by the model.

The effect of impeded drainage is supported by the data obtained for both 1975 and 1976 growing seasons. Specifically, the model predicted runoff and drainage losses between 12.7 and 13.5 cm for the four profiles studied following 17.4 cm of rain during June 8, 9 and 10, 1975. Predicted drainage losses accounted for 56% of the above total losses (Table 4). If we assume that the model predicted runoff losses correctly, moisture redistribution rates in Solonetzic soils are too low to justify the losses predicted by the model within a period of 3 days. Moreover, the total actual evapotranspiration values predicted by the model at the end of the growing season (17.76 to 18.36 cm) are too low to justify the yields obtained (Anderson and Wilkinson, 1977).

A number of simple calculations presented in Table 4 demonstrate the serious errors that have been introduced because of the discrepancies which occurred between the infiltration and redistribution rates used by the model and those occurring under natural conditions. In these calculations, it is assumed that the total leaching losses obtained for June 8, 9 and 10, 1975 did not actually occur. Hence, the water lost is returned into the profile. The corrected values for the soil moisture levels predicted for June 24, 1975 are in close agreement to those

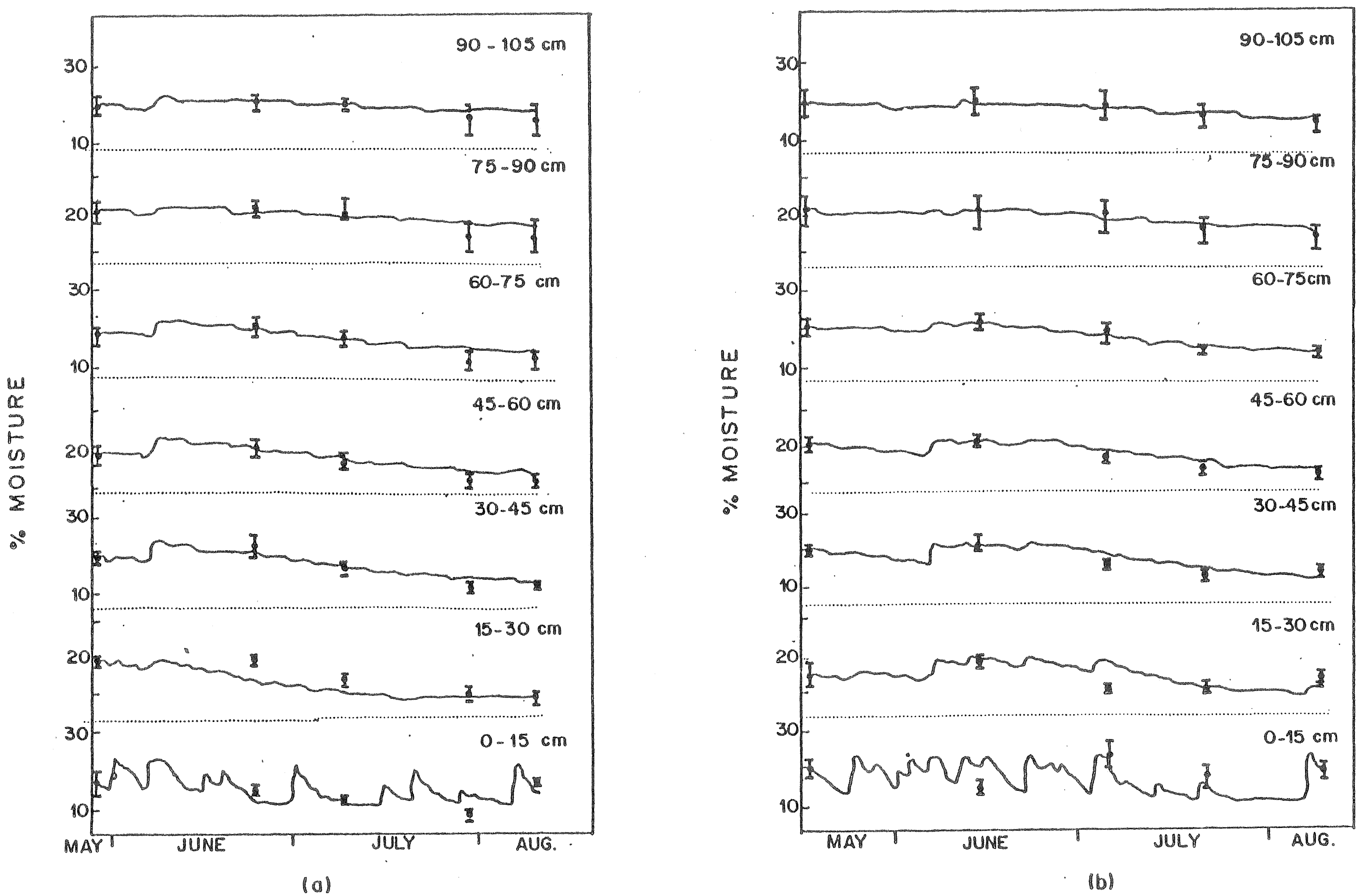

Fig. 4. Model output; Orthic Dark Brown profile (a - 1975; b - 1976).

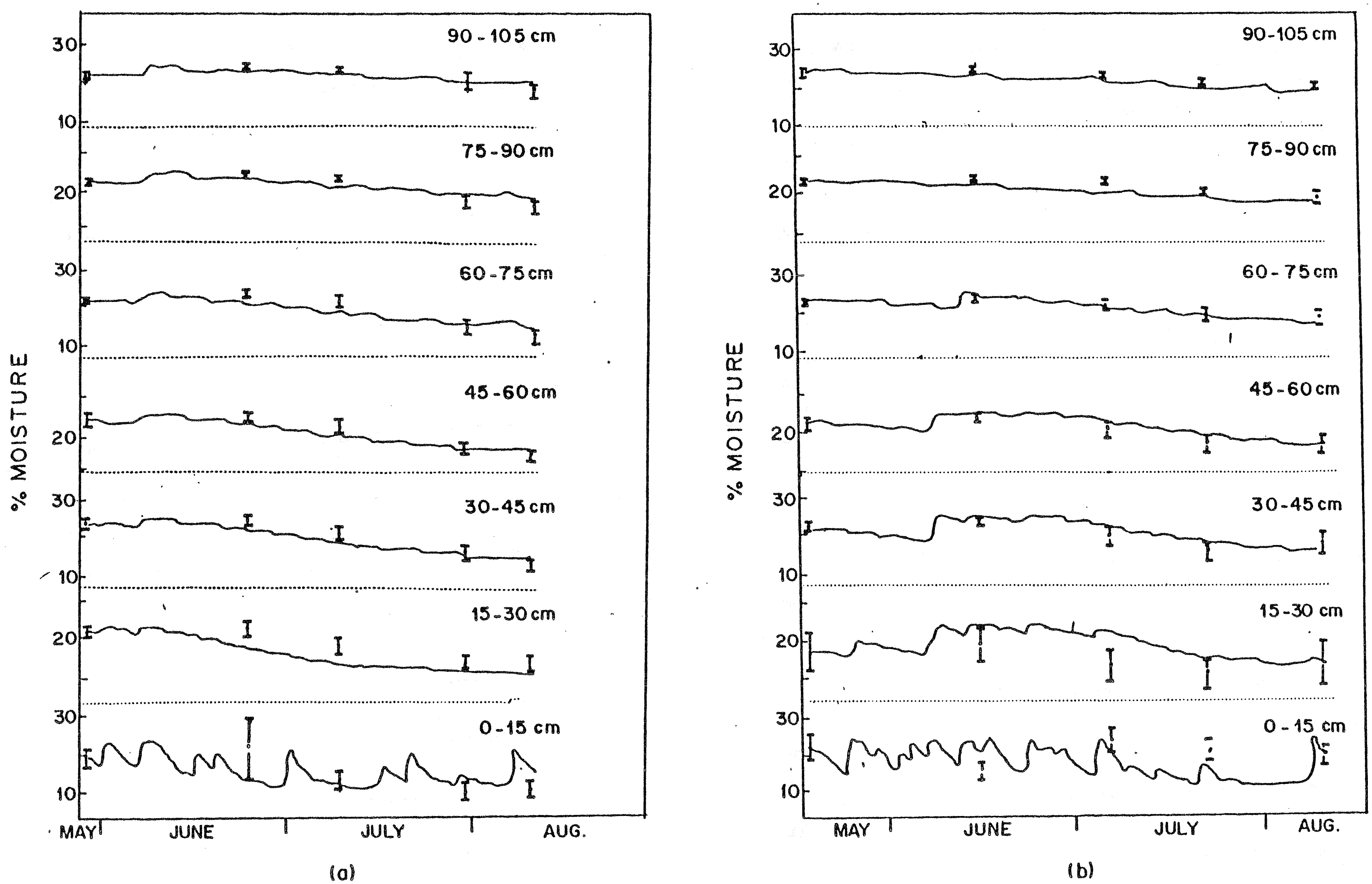

Fig. 5. Model output; Solonetzic Dark Brown profile (a - 1975; b - 1976).

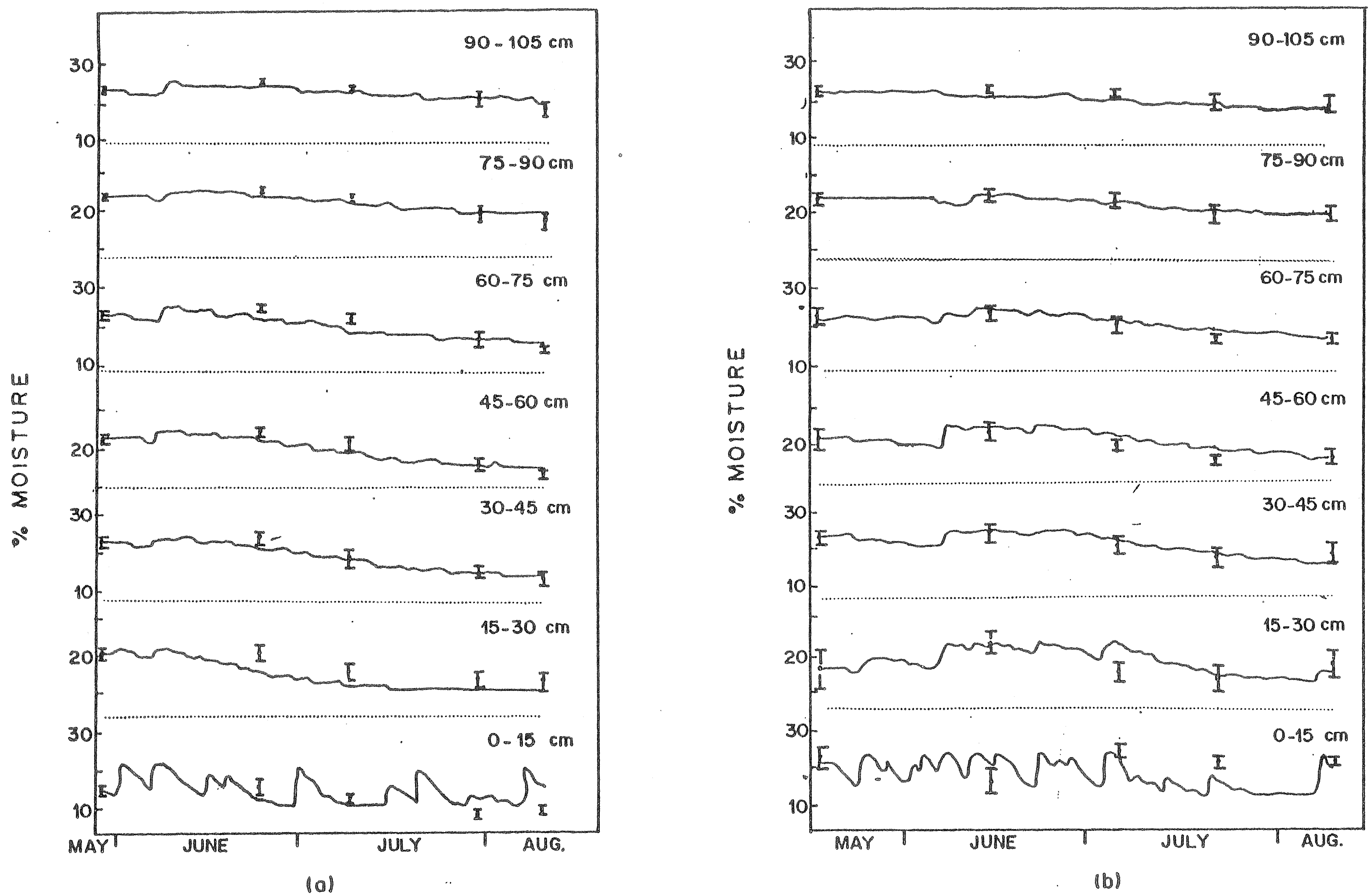

Fig. 6. Model output; Solodic Dark Brown profile (a - 1975; b - 1976).

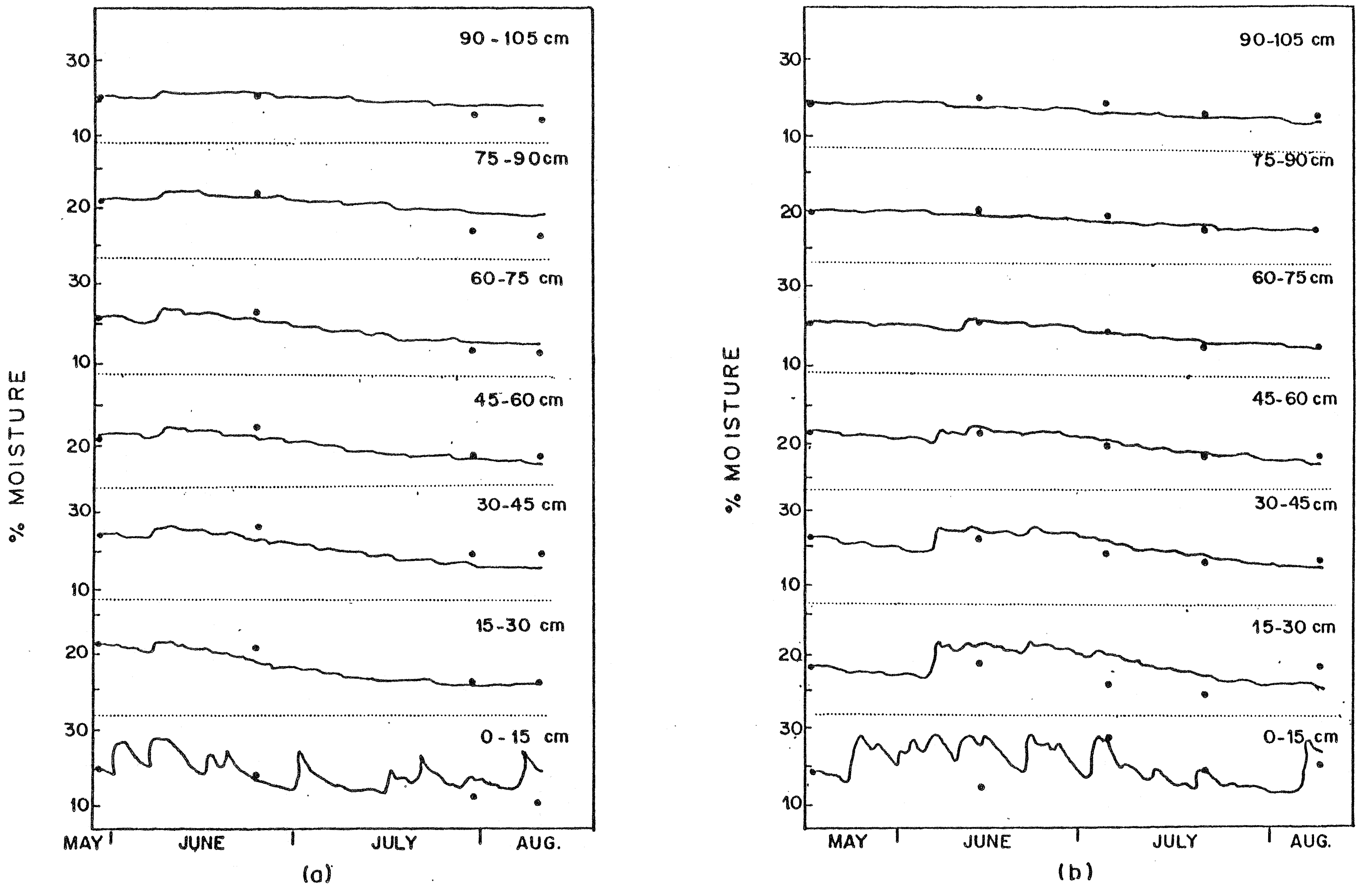

Fig. 7. Model output; Dark Brown Solodized-Solonetzic profile (a - 1975; b - 1976).

Table 4. Predicted soil moisture contents (June 24, 1975) corrected for leaching losses.

	Orthic D. Brown	Solonetzic D. Brown	Solodic D. Brown	D.B. Solodized-Solonetz
(A) Precipitation, June 10-24, 1975, cm	1.53	1.53	1.53	1.53
(B) Leaching losses, June 8-10, 1975, cm	7.04	7.93	7.78	7.48
(C) TOTAL INPUT	8.57	9.46	9.31	9.01
(D) Actual evapotranspiration, June 10-24, 1975, cm	5.38	5.45	5.39	5.55
(E) NET GAIN (C - D)	3.19	4.01	3.92	3.46
(F) Predicted soil moisture, June 24, 1975, cm	8.82	9.75	9.36	10.06
(G) Corrected soil moisture, June 24, 1975, cm (F + E)	12.01	13.76	13.28	13.52
(H) Actual soil moisture, June 24, 1975, cm	10.72	13.56	12.19	12.55

obtained under field conditions, except those predicted for the Orthic Dark Brown profile, which are much higher than the actual ones.

The discrepancies obtained in the 1976 values could also be attributed to differences between the moisture redistribution rates in the profile used by the model and those occurring under field conditions. Following precipitation the moisture input is distributed to the whole profile on the basis of the field capacity and permanent wilting point values of each soil zone. However, under field conditions, the movement of soil moisture to greater depths is much slower than the predicted one. Water resides in the Ap horizons for longer periods of time due to the presence of the hard and impermeable Bnt horizons. Hence, the predicted soil moisture values for the top layers are lower than the actual ones and, in contrast, those for the lower layers are higher than the actual ones.

CONCLUSIONS

This paper attempted to utilize the "Versatile Moisture Budget" to predict moisture redistribution during the growing season in a sequence of soil profiles in the Weyburn area.

The discrepancies obtained between the predicted and actual soil moisture levels are attributed to the inability of the drainage function utilized by the model to predict water redistribution rates in the Solonetzic soils of the area under consideration. Hence, the model may work well for soils that approach field capacity within 24 hrs but major changes should be introduced to account for the slow moisture redistribution rates in the Solonetzic soils.

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